I. C. 7443 APRIL 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
JAMES BOYD, DIRECTOR

INFORMATION CIRCULAR

EXPLORATION, DEVELOPMENT, MINING, AND MILLING OF A UNIQUE TUNGSTEN ORE BODY AT THE YELLOW PINE MINE, STIBNITE, IDAHO

RECEIVED
MAY 15 1948
U. S. U. LIBRARY

BY

JOHN W. COLE AND H. D. BAILEY

Generated on 2024-09-19 18:56 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

I. C. 7443,
April 1948.

INFORMATION CIRCULAR

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

EXPLORATION, DEVELOPMENT, MINING, AND MILLING OF A UNIQUE TUNGSTEN ORE BODY AT THE YELLOW PINE MINE, STIBNITE, IDAHO[1]

By John W. Cole[2] and H. D. Bailey[3]

CONTENTS

	Page
Introduction	2
Acknowledgments	3
History and production	3
Physical features and communications	5
General	5
Cost of transportation	5
Utilities	5
Power	5
Water supply	6
Description of deposits	6
General geology	6
Ore deposits at Yellow Pine mine	6
Exploration by Bureau of Mines	7
Plan of operations	7
Diamond-core-drilling methods and costs	8
Diamond-drill sampling methods and costs	9
Method of calculating ore reserves	10
Exploration by company	11
General	11
Diamond-core-drilling methods and costs	11
Development	11
Plan of operations	11
Development of underground mine	12
Development of open-pit mine	12
Stream diversion	12
Bailey tunnel costs	12
Stripping	13
Mining	13
Underground mining	13
Open-pit mining	14

1/ The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7443."

2/ Mining engineer, Mining Division, Bureau of Mines, Spokane, Wash.
3/ Manager, Yellow Pine mine.

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

CONTENTS (Cont'd.)

	Page
General plan of operations	14
Drilling	15
Blasting	16
Loading	16
Trucking	17
Drainage	17
Milling	17
Crushing	18
Grinding	18
Flotation	19
Iron sulfide (gold) circuit	19
Antimony sulfide circuit	19
High-grade tungsten circuit	20
Low-grade tungsten circuit	20
Summary of costs - open-pit mining and milling	21
Mining and milling costs in dollars	21
Mining and milling costs in units of labor and supplies	22
Appendix	23
Wage scale, Yellow Pine mine and mill May 1, 1946	23
Organization chart	24

ILLUSTRATIONS

Fig.		Following page
1.	Stibnite and vicinity	2
2.	Ore deposits and drill holes - Yellow Pine mine	2
3.	Section on A-A' (fig. 2) - Yellow Pine mine	6
4.	Plan of open pit workings - Yellow Pine mine	10
5.	Section A-A' across open pit - Yellow Pine mine	10
6.	Typical open pit drill round	14
7.	Flow sheet - Yellow Pine mill	19

INTRODUCTION

This paper is one of a series on mining methods and costs published by the Bureau of Mines. Because of the role played by the Federal Government in the discovery of the ore body, a description of the exploratory operations of the Bureau of Mines is included.

Generated on 2024-09-19 18:56 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

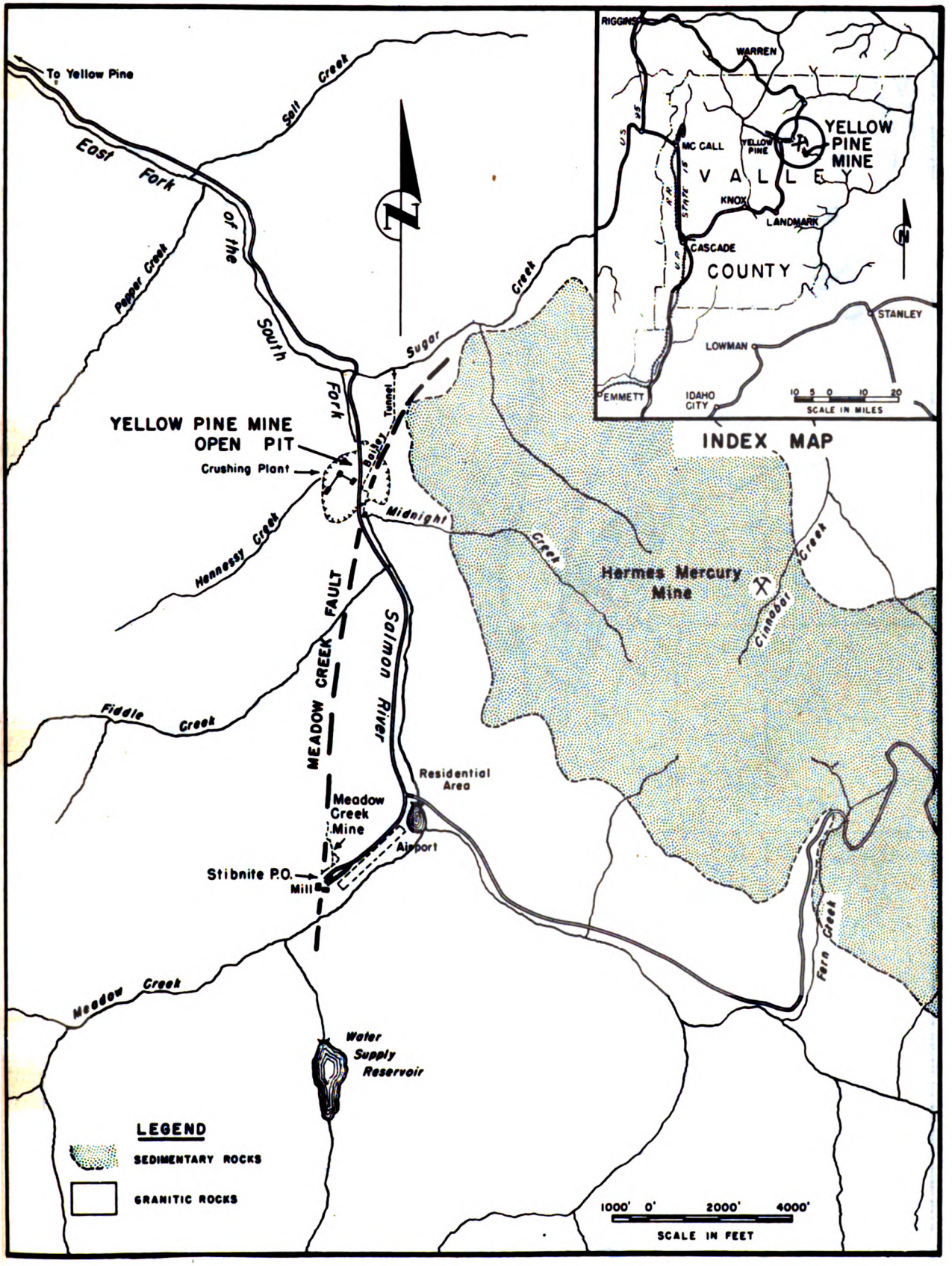


Figure 1. - Stibnite, Idaho, and vicinity.

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

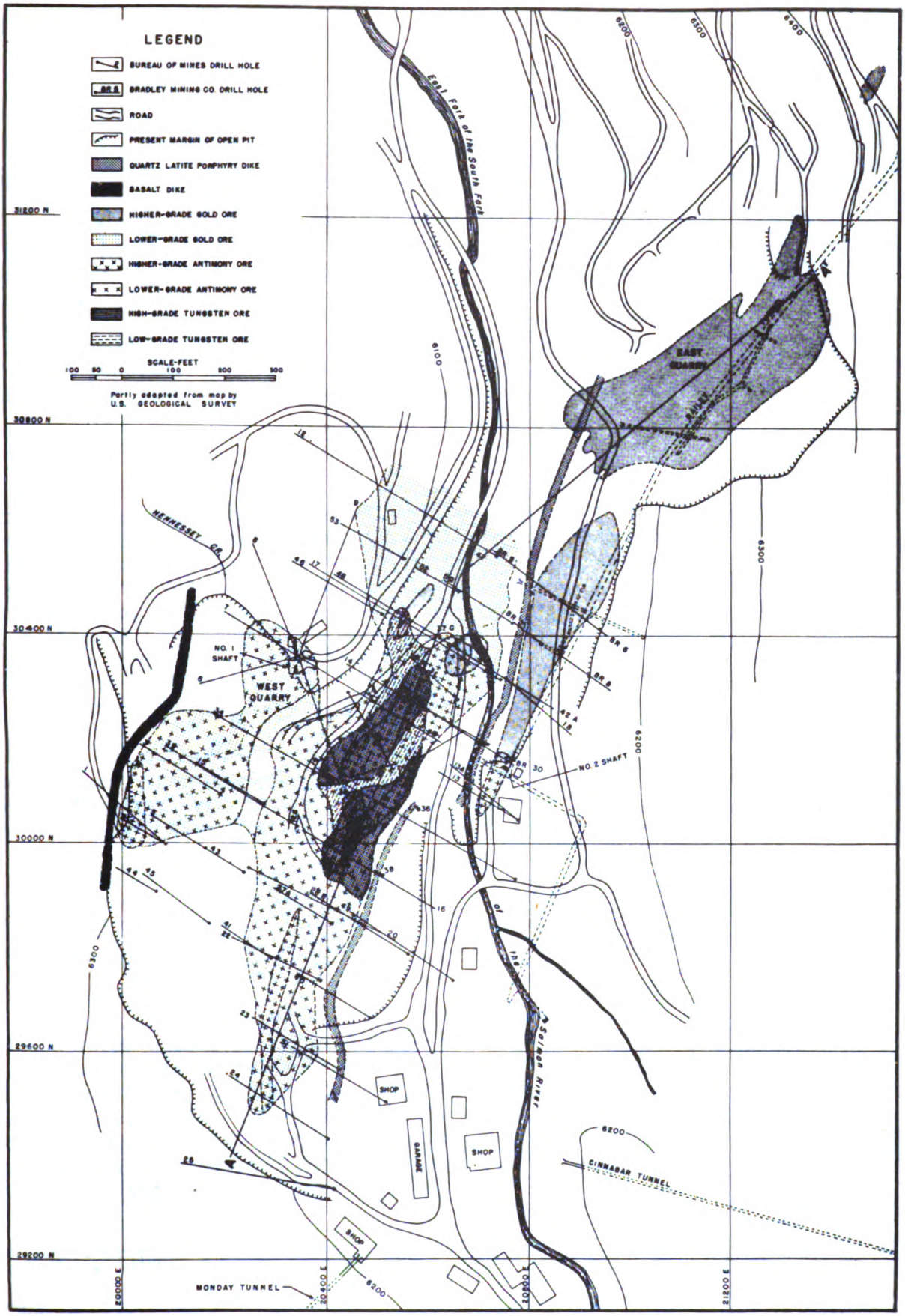


Figure 2. - Ore deposits and drill holes, Yellow Pine mine.

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

ACKNOWLEDGMENTS

The studies of mining methods and costs are conducted by the Mining Division of the Bureau of Mines under the supervision of Lowell B. Moon, chief.

Acknowledgment is made to the Bradley Mining Co. for its cooperation in making available data for the methods and costs section of the paper and to the members of their staff for helpful suggestions concerning material to be included.

Free use has been made of information contained in unpublished Bureau of Mines reports. The suggestions and criticisms of S. H. Lorain,[4/] who directed the Bureau of Mines exploration, have been particularly helpful.

HISTORY AND PRODUCTION

The existence of gold-antimony mineralization near the present site of Stibnite has been known since the Thunder Mountain gold rush in 1900. However, the first record of claim locations is in 1914, when Albert Hennessy staked the claims which are now known as the Meadow Creek and the Hennessy groups. Later these claims were acquired by the United Mercury Mines Co., Boise, Idaho. In August 1927, F. W. Bradley, San Francisco, Calif., obtained an option on the Meadow Creek group and in 1933 on the Hennessy group, on which the tungsten ore body later was discovered. The operating company was known as the Yellow Pine Co. until 1938, when all of its assets were acquired by the parent company, the Bradley Mining Co.

The Yellow Pine Co. constructed a 150-ton mill on Meadow Creek, (fig. 1), and produced antimony-gold ore from the underground workings of the Meadow Creek mine from 1932 to 1938. The Meadow Creek mine was closed in July 1938, and operations were shifted to the Hennessy group of claims.

During 1938 and part of 1939 antimony-gold ore was mined from an open pit known as the West quarry (fig. 2). In 1939, operations were shifted from the West quarry to the East quarry because the ore in the East quarry contained less antimony and more gold. The mill capacity was increased to 450 tons a day in 1939.

During the winter of 1939-40, a Bureau of Mines drilling program disclosed large bodies of comparatively high-grade antimony ore under the East Fork valley between the East and West quarries. Scheelite first was recognized in February 1941 by Donald E. White, a geologist of the Federal Geological Survey, during a microscopic examination of thin sections from Bureau of Mines drill cores. Subsequent examination of the core and sludge samples revealed exceptionally high-grade tungsten ore in close association with the high-grade antimony ore under East Fork Valley.

4/ Chief, Albany Branch, Mining Division, Bureau of Mines, Albany, Oreg.

Generated on 2024-09-19 18:58 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

A shaft was started in April 1941. By the end of that year all mining had been shifted to the tungsten-antimony-gold ore body.

The ore was mined from underground workings while an open pit was being developed. The mill capacity was expanded to 750 tons a day. By 1943 ore was being produced from an open pit at the rate of nearly 180,000 tons a year. During the first year of large-scale production, 300,000 units of tungsten trioxide, 4,000 tons of antimony, 5,000 ounces of gold, and 150,000 ounces of silver were recovered.

The tungsten ore body was exhausted in July 1945. Retreatment of the tailings from the tungsten operation was completed in December 1945.

The following tables give the production from the district by the Yellow Pine Co. and its successor, the Bradley Mining Co.

TABLE 1. - Production from the Meadow Creek Mine

Year	Mined, tons	Concentrates, tons	Metal content of concentrates		
			Sb, tons	Au, oz.	Ag, oz.
1932..	34,366	3,242	489	6,915.76	18,488
1933..	45,710	3,534	588	10,411.85	29,817
1934..	54,000	3,735	404	10,491.36	25,384
1935..	50,965	3,602	550	8,373.38	25,217
1936..	43,324	3,787	729	7,797.96	32,615
1937..	39,521	3,246	755	5,514.00	36,572
Total.	267,886	21,146	3,515	49,504.31	168,093

TABLE 2. - Production from the East and West quarries

Year	Mined, tons	Concentrates, tons	Metal content of concentrates		
			Sb, tons	Au, oz.	Ag, oz.
1938..	38,880 1/	2,200	379	3,529.00	17,687
1939..	56,074	2,677	228	5,810.00	14,844
1940..	132,297	4,521	18	12,401.00	15,825
1941..	80,658 2/	3,323	13	8,280.00	9,994
Total.	304,909	12,721	638	30,020.00	58,350

1/ Includes about 5 months' operation of Meadow Creek mine.
2/ To start of tungsten mining.

TABLE 3. - Production from tungsten ore body

Year	Mined, tons	Concentrates, tons	Metal content of concentrates			
			WO_3 units	Sb, tons	Au, oz.	Ag, oz.
1941..	14,498 1/	2,466	27,921	367	2,055	8,987
1942..	96,861	15,210	181,230	2,801	2,714	85,161
1943..	178,747	22,787	303,502	2,734	4,529	109,307
1944..	211,382 2/	13,438	233,664	2,031	6,110	74,498
1945..	109,796	7,590	85,512	2,895	6,505	87,815
Total.	611,284	61,491	831,829	10,828	21,913	365,768

1/ Starting in August 1941.
2/ Includes 966 tons of tailings re-treated.

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

PHYSICAL FEATURES AND COMMUNICATIONS

General

The mine is in an isolated mountain area of central Idaho. Altitudes range from 6,000 feet at the mine to 8,000 feet at the summits of adjacent ridges. Slopes are steep but not precipitous; most of them are covered uniformly with brush and small timber. The valleys are covered deeply with glacial till. Prior to diversion, the East Fork of the South Fork of the Salmon River flowed through the length of the mine property. The stream flow is approximately 300 second feet of water at high water stage.

Summers are cool and dry. Winter temperatures of 30 to 40 degrees below zero are common. Snow lies on the ground from November to May; it usually accumulates to depths of 4 to 6 feet.

The nearest paved highway is at Cascade, Idaho, which is also on a branch line of the Union Pacific railroad. Seventy-eight miles of mountain road connects Cascade with Stibnite. Between Cascade and the settlement of Yellow Pine, this road crosses two summits 6,800 and 7,300 feet, respectively, above sea level. From the second summit the road descends to an altitude of 4,500 feet at Yellow Pine and then climbs to 6,500 feet at Stibnite post office. In years previous to 1942, this road was blocked with snow from November to May. During the war it was kept open throughout the winter to permit transportation of tungsten concentrates; nevertheless, it usually has been impassable because of deep mud for several weeks each spring. Airplane service is maintained between Stibnite and Boise and, when the mine road is closed, between Stibnite and Cascade.

Cost of Transportation

Ten Diesel-powered dump trucks, including one Fageol, two Sterlings, and six Autocars, were used during 1945 to haul concentrates from Stibnite to Cascade and to Boise, and to haul supplies back to the mine. A total of 1,738,742 ton-miles was hauled at an operating and maintenance cost of $0.0706 a ton-mile. This compares with a cost of $3.00 to $4.00 a ton,5/ or $0.04 to $0.05 a ton-mile for hauling concentrates from Stibnite to Cascade in 1941.

UTILITIES

Power

All mining equipment is driven by Diesel or gasoline power units. Until 1943 electric power was generated by 3 hydroelectric plants capable of producing 850 horsepower at maximum water flow and 14 Diesel-electric generators with a rated capacity of 2,800 horsepower. In 1943 the Idaho Power Co. completed construction of 110 miles of 66,000-volt transmission line from

5/ Bradley, John D., Mining and Milling Methods and Costs at the Yellow Pine Mine, Stibnite Idaho: Bureau of Mines Inf. Circ. 7194, 1942, p. 10.

Generated on 2024-09-19 18:56 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Emmett, Idaho. Amortization charges covering construction of the transmission line are $2,100 a month for a period of 5 years. Bradley Mining Co. and other consumers are assessed a proportionate part of this charge. Electric power consumed by the Bradley Mining Co. during 1945 was 6,470,000 kilowatt-hours. The cost was $0.01 a kilowatt-hour. Electric power for domestic purposes is provided by the mining company and is included in the above figure.

Water Supply

Water for milling and domestic purposes is obtained from a reservoir formed by a dam across the South Fork of Meadow Creek (fig. 1). Chlorinators are used for water purification.

DESCRIPTION OF DEPOSITS

General Geology

The general geology of the district has been described in published reports by Schrader and Ross,6/ and by Currier.7/ The tungsten and antimony deposits have been further described in an unpublished report by White.8/

The following description of the general geology is derived principally from data contained in these reports.

The deposits are in granodiorite of the Idaho batholith. They are near the southwestern contact of a large roof pendant of highly metamorphosed sedimentary rocks, which are probably of lower Paleozoic age. A strong fault, known as the Meadow Creek fault, is in the granodiorite a short distance west of the sedimentary contact (fig. 1). This fault has been traced from the Meadow Creek mine north to the East quarry, where it bends to the northeast around the northern end of the sedimentary roof pendant. The principal gold-antimony-tungsten ore deposits are adjacent to the Meadow Creek fault zone, but smaller deposits occur in the granodiorites and metamorphosed sediments at various places within an area extending about 1 mile east from the fault. This paper is particularly concerned with the ore bodies at the Yellow Pine mine. This mine is near the northern end of the Meadow Creek fault where it changes direction from north to northeast.

Ore Deposits at Yellow Pine Mine

The ore bodies at the Yellow Pine mine are distributed irregularly within an area 2,000 feet long by 100 to 600 feet wide (fig. 2). Gold-bearing iron

6/ Schraeder, F. C., and Ross, C. P., Antimony and Quicksilver Deposits in the Yellow Pine District, Idaho: Geol. Survey Bull. 780, 1926, pp. 137 - 164.

7/ Currier, L. W., A Preliminary Report on the Geology and Ore Deposits of the Eastern Part of the Yellow Pine District, Idaho: Idaho Bureau of Mines and Geology, Pamph. 43, 1935, 27 pp.

8/ White, D. E., Tungsten and Antimony at Yellow Pine Mine, Valley County, Idaho: Geol. Survey Memorandum Report, 1942.

Generated on 2024-09-19 18:56 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

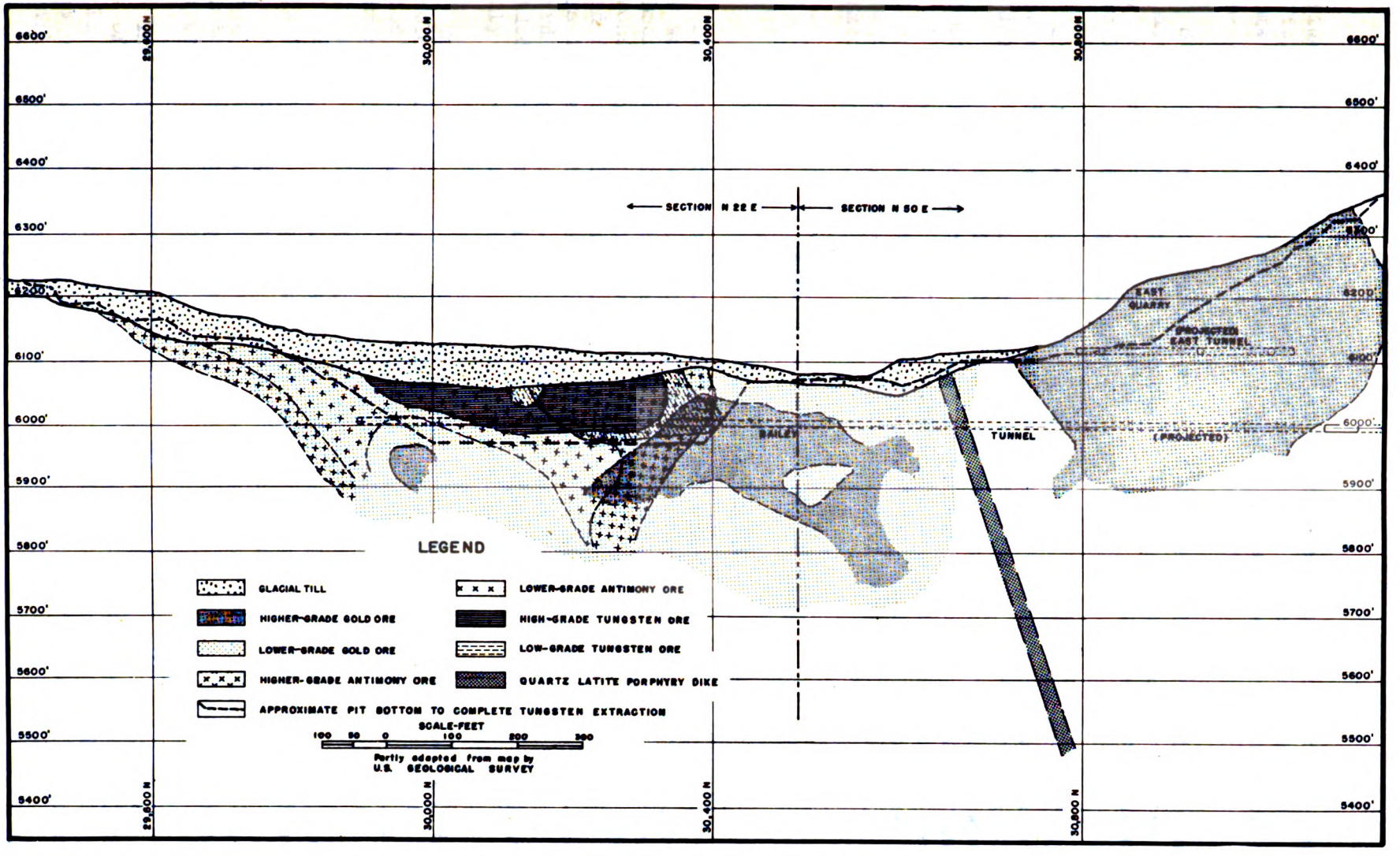


Figure 3. - Section on A-A' (fig. 1), Yellow Pine mine.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

sulfides are disseminated throughout the entire mineralized area. They are sufficiently abundant to constitute ore in the northeastern part, but they become progressively less abundant toward the southwestern limits of the area.

Stibnite was most abundant near the center of the area; it is also abundant in the West quarry area and in a long, relatively narrow ore body a short distance south of the central ore body. Stibnite is disseminated very sparsely in the East quarry area.

Scheelite was confined almost entirely to the central area. It was associated intimately with the highest-grade antimony ore. It occurred principally in small veinlets and disseminated grains. The richest tungsten ore was in the central and eastern parts of the tungsten-bearing block where one 60-foot drill-core section averaged 16 percent tungsten trioxide. The tungsten trioxide content of the ore diminished to a fraction of one percent toward the western and southern margins of the tungsten bearing area. The tungsten ore body extended to a depth of approximately 175 feet below the surface (fig. 3).

EXPLORATION BY BUREAU OF MINES

Plans of Operations

Field work by the Bureau of Mines was started August 23, 1939. This work was undertaken with the object of discovering a strategic reserve of antimony ore. At that time, operations on the West quarry ore body had been suspended by the mining company, and the East quarry was being developed and mined for its gold content. The results of trenching and sampling in nearby areas indicated that antimony mineralization became progressively stronger toward the general area of the East and West quarries. Therefore, it was decided that some drilling would be justified in the vicinity of the relatively high-grade antimony ore of the West quarry.

On November 3, 1939, a diamond-drilling project was started at the site of hole 1 (fig. 2) and was continued until February 28, 1940. During this period 11 holes were drilled. The first few holes proved that low-grade antimony ore extended a considerable distance southerly from the West quarry and that it terminated to the west against an easterly dipping basic dike. Hole 10 was then drilled easterly under the valley. It penetrated 110 feet of exceptionally good antimony ore under the middle of the valley where the ore was concealed by about 50 feet of glacial till. This discovery was confirmed by hole 11. The project was then recessed until July 17, 1940, when a systematic program was started to determine the size, shape, and grade of this ore body.

The drilling program was planned to develop vertical sections at intervals of approximately 110 feet, starting with the ore intersected by hole 10 and 11 and following the ore body to the north and to the south. The positions of the 52 holes drilled by the Bureau of Mines are shown on figure 2. The drilling program was completed June 22, 1941.

Generated on 2024-09-19 18:56 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Immediately after recognition of scheelite in the drill cores, the Bradley Mining Co. instituted an aggressive program of drilling and development. This relieved the Bureau of Mines of the necessity for further delimiting the tungsten ore body.

Diamond-Core-Drilling Methods and Costs

All drilling was performed by contractors. One drill was operated two shifts a day during the initial period, November 1939 to February 1940. During the later period of drilling, July 1940 to June 1941, one drill was operated two to three shifts a day until May 1941. At that time a second drill was placed in operation.

During the first period of drilling all holes were started in bedrock and drilled with EX bits. To obtain satisfactory sludge recovery from the highly fractured rock, these holes had to be cemented throughout their length. During the second period of drilling the holes were started in overburden by driving 3-inch pipe to bedrock. The bit size was reduced successively from BX to AX to EX. This drilling procedure permitted the use of casing to seal the hole through fractured sections - cement was used only at infrequent intervals. The recovery of drill sludge was more consistent during the second period, and less drilling time was lost. Careful analysis of the cost of the two drilling procedures shows that the second method cost about $1.00 less per foot of hole than the first method.

The overburden was glacial till composed chiefly of rocks and boulders ranging up to several feet in diameter. Three-inch extra-heavy pipe was advanced through the glacial till by the usual methods of driving, drilling, and blasting. The longest distance drilled through overburden was 119 feet. The average depth of overburden in the holes was 57 feet. The cost of drilling through overburden was $4.56 a foot.

The following table gives units of work completed by the Bureau of Mines:

TABLE 4. - Work completed by Bureau of Mines drilling program

Period covered: November 3, 1939, to February 28, 1940;
September 29, 1940, to June 22, 1941.

Number of holes drilled: 52

Footage drilled:	
Overburden	1,408.0
Size BX	1,520.5
Size AX	3,182.5
Size EX	9,763.0
Total	15,874.0

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 4. - Work completed by Bureau of Mines drilling program (Cont'd.)

Footage core recovered	5,670.0
Percent core recovered	35.7
Footage reamed	558.5
Footage casing placed	1,707.5
Footage cemented	2,248.0
Drill shifts worked	958.0
Man-shifts worked by contractor	2,406.0
Man-shifts worked by Bureau employees	1,258.5
Average footage drilled per machine shift	16.6
Number of samples taken	5,390.0

A summary of the diamond drilling costs follows:

Item	Cost		
	Amount	Per foot drilled	Per sample taken
Contract			
Drilling	$43,299.59	$2.73	$8.04
Reaming and casing	800.38	.05	.15
Cementing	3,308.30	.21	.61
Extras	914.25	.06	.17
Force account (Bureau of Mines)			
Labor	720.62	.04	.13
Supplies	105.14	.01	.02
Supervision	2,786.85	.17	.52
Transportation	141.17	.01	.02
Miscellaneous	149.25	.01	.03
Totals	$52,225.55	3.29	9.69

Diamond-Drill Sampling Methods and Costs

The Bureau employed a diamond drill sampler for each shift. His duties were to check the work accomplished by the drill contractor and to collect and care for the core and sludge samples.

Sludge samples were collected in wood or metal settling tanks, 10-inch by 10-inch by 8-foot in size; they were constructed with cross baffles to aid settling. The overflow from the settling tanks was collected in 50-gallon steel drums to permit further settling of the finer particles. Addition of lime to the returned drill water was found to aid settling by coagulating the slimes. After each run of approximately 5 feet, the sludge was collected from the settling tanks and drums and dried in galvanized-iron tubs over a wood fire. After drying, the samples were weighed and sacked.

Drill cores were measured and weighed by the sampler and filed in conventional-type wood core boxes. Later the core was split; one-half was assayed, and the other half was filed for future reference.

More effort and expense were devoted to sampling than is customary in drilling operations performed by mining companies because it was desired to

Generated on 2024-09-19 18:59 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

determine accurately the quantity and grade of ore by the drilling method alone, and the results were to be filed as official Government records.

An itemized statement of the cost of sampling follows:

Item	Cost		
	Amount	Per sample	Per foot drilled
Labor	$7,224.52	$1.34	$0.45
Supplies	883.32	0.16	.05
Supervision	1,202.49	.22	.08
Transportation	894.53	.17	.06
Miscellaneous	7.15	-	-
Total	10,212.02	1.89	.64

Method of Calculating Ore Reserves

The analysis of the core was accepted where the core recovery exceeded 95 percent of the sample interval. When the core recovery was less than 95 percent an adjusted average of core and sludge analyses was computed by use of the following formula:

$$A = \frac{A_1 W_1 + A_2 W_2}{W_1 + W_2},$$

where A is the adjusted average analysis; A_1 is the analysis of the core sample; A_2 is the analysis of the sludge sample; W_1 is the weight of core recovered; and W_2 is the weight of the sludge that, theoretically, should be recovered.

The average antimony, gold, and silver content of each class of ore in a drilled section was computed from the weighted analyses. The volume of each ore block was determined by multiplying one-half the sum of the areas of the end sections by the distance between them. The weighted average analyses of the end sections were used to determine the average grade of the ore in the block. A factor of 10 cubic feet to a ton was used to convert volume to weight.

Estimates of the tungsten content of the ore was based on incomplete drilling of the higher-grade tungsten ore bodies. The actual recovery of tungsten was 16 percent higher than preliminary Bureau of Mines estimates. It is not possible at this time to compare actual production of gold, silver, and antimony with Bureau of Mines estimates because only the ore that contained tungsten was milled. Data that are now available indicate that the final antimony recovery will be very close to Bureau of Mines estimates.

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

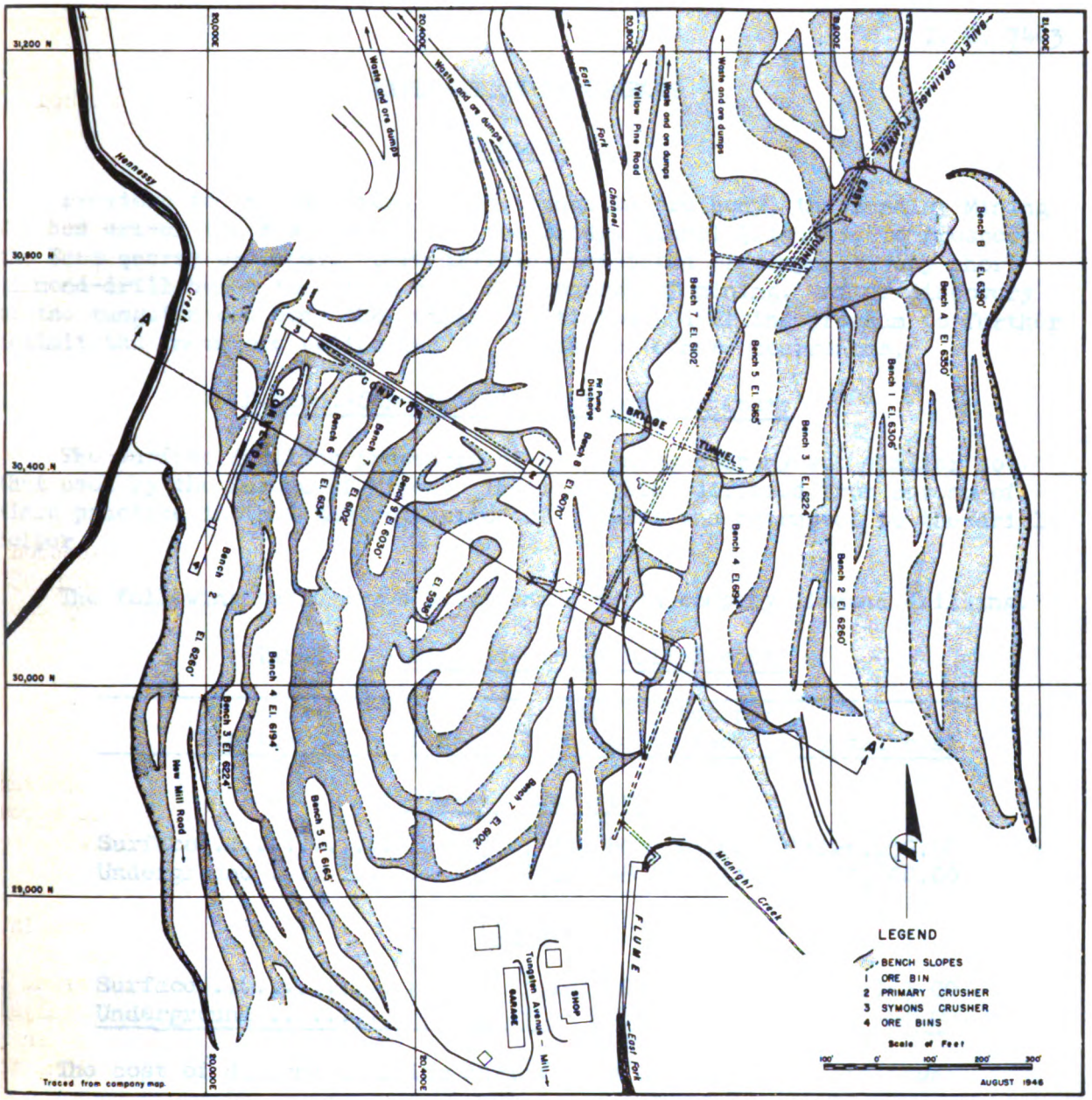


Figure 4. - Plan of open-pit workings, Yellow Pine mine.

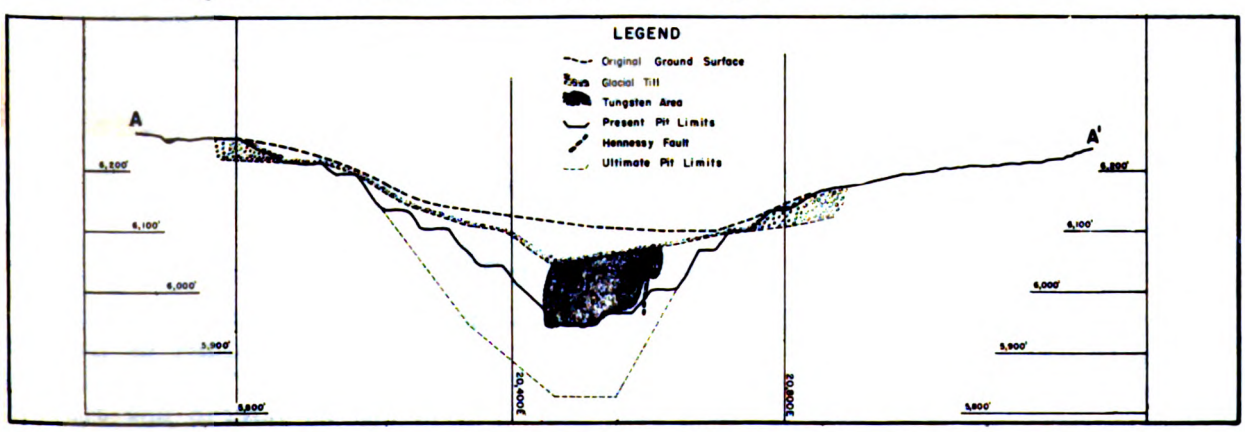


Figure 5. - Longitudinal section A-A' across open pit, Yellow Pine mine.

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

EXPLORATION BY COMPANY

General

Previous to the discovery of the tungsten ore body, the Bradley Mining Co. had driven the East tunnel and the Bridge tunnel (fig. 4), to prospect the East quarry ore body. Core drilling consisted of comparatively short diamond-drill holes to obtain data for control of mining. After discovery of the tungsten ore body the company initiated a drilling program to further delimit the known ore bodies and to search for other occurrences.

Diamond-Core-Drilling Methods and Costs

The surface drilling procedure of the mining company was similar to that used by the Bureau of Mines. Their sampling differed from Bureau of Mines practice in that the collection of samples was entrusted to the drill helper.

The following table gives pertinent data on company diamond drilling.

TABLE 5. - Diamond-core-drilling costs

Station	No. of holes	Total footage	Cost per foot	Total cost
(1939-44, inclusive)				
Surface	133	34,886	$3.62	$126,252.00
Underground	81	12,288	2.75	27,500.00
(1945)				
Surface	52	10,110	2.39	24,143.00
Underground	1	105	2.39	251.00

The cost of diamond drilling during 1945 is itemized as follows:

	Cost per foot
Labor	$1.40
Supplies and miscellaneous	.268
Diamond bits	.722
Total	$2.39

DEVELOPMENT

Plan of Operations

In order to check the results of core drilling and to start producing tungsten as rapidly as possible, the sinking of a vertical shaft was started in April 1941 (fig. 2). The shaft was sunk to a depth of 175 feet, and a crosscut was driven to the ore.

Generated on 2024-09-19 18:59 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The core drilling and subsequent underground development proved that the tungsten ore body was adapted to open-pit mining methods. Underground mining was continued until the open pit was developed and ready for operation.

Development of Underground Mine

The underground mine workings in the tungsten ore body consisted of a vertical shaft 175 feet deep, a vertical winze 103 feet deep, an inclined shaft 165 feet deep, 4,000 feet of drifts and crosscuts, and several raises. These workings were destroyed by the subsequent open pit mining operations.

Development of Open-pit Mine

Stream Diversion

Before open pit mining operations could be started it was necessary to divert the flow of water from the existing channel of the East Fork. The topography of the area permitted the construction of a diversion tunnel (Bailey tunnel, fig. 1) from Sugar Creek to intersect the East Fork at a point upstream from the open pit. The total length of the tunnel and the raises from it is approximately 4,000 feet. The tunnel was started in 1942 and completed early in 1943. It was driven from the Sugar Creek end and also from the underground mine workings on the East Fork. The cross section of the tunnel is 10 feet 6 inches high by 9 feet wide. It is timbered throughout its length. The posts are 10 inches by 10 inches by 9 feet; the caps are 10 inches by 10 inches by 7 feet. Raised sills, 6 inches by 10 inches by 6 feet 6 inches, provide space for a ditch 6-1/2 feet wide by 2 feet deep. During low water season the upper section of the tunnel is free of water.

Bailey Tunnel Costs

During the 4-month period, November 1942 to February 1943, the headings in the Bailey tunnel were advanced 2,124 feet. The following table gives detailed costs of tunneling during that period.

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 6. - Tunnel costs, November 1942 - February 1943

	Costs per foot	
	Dollars	Man-hours
Labor		
Drilling	$3.90	2.19
Mucking	6.84	3.89
Timbering	1.60	2.35
Pipe and track	1.73	.97
(Compressor operators		
(Timber framer		
Other	8.20	4.64
(Truck driver		
(Electrician		
(Mechanic		
(Engineering		
(Dump labor		
Total labor	$22.27	14.04
Supplies		Units
Explosives	2.40	20.55
Timber	.41	pounds
Miscellaneous (including Diesel oil)	6.43	
Air and water pipe	.79	
Rails	.29	
Drill bits	.59	
Total supplies	$10.91	
Total supplies and labor	$33.18	

Stripping

It was necessary to remove approximately 830,000 tons of glacial till to expose the tungsten ore body for open-pit mining (fig. 5). The equipment employed during preliminary stripping included 5 power shovels, 10 Diesel-driven tractors, 25 Diesel-driven trucks, and 25 gasoline-driven trucks. Part of the waste dumps are on both sides of the East Fork channel downstream from the pit; the remainder are on the south side of Sugar Creek, (fig. 1). The maximum length of waste haul is approximately 2,000 feet.

MINING

Underground Mining

The following description of the operation of the underground mine is quoted from Bradley, Mecia, and Baker:9/

> The underground workings are distributed over three levels, and consist of a 175-foot vertical shaft, a 165-foot inclined shaft, a

9/ Bradley, John D., Mecia, Joseph A., and Baker, Robert E., Yellow Pine Mine: Eng. and Min. Jour., April 1943, pp. 60-66.

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

a 103-foot vertical winze, 4,000 feet of drifts and crosscuts, and several raises and stopes. I-R DA30 and DA35 machines are used in crosscutting and drifting. Fifteen to twenty holes, using a V-cut, are drilled in establishing lateral workings with a 6- by 8-foot cross section. Broken ore on the lower two levels is loaded with Eimco Model 12B loaders, and I-R Model 4NNOJ slushers are used in the drifts and crosscuts on the upper level. The ore on the upper level either is scraped into transfer raises or loaded directly into 18-cubic foot end dump cars by using a slusher and ramp. In the lateral headings about 6 tons per man-shift is produced at a cost of $2.78 per ton. The drifting crew consists of a miner and helper on one shift, and a loader operator for half of the next shift. Drilling in the square-set stopes is done with I-R R58 stopers, with the stope crew comprising a miner and a helper on each shift. The two do all the mining, mucking, timbering, and filling in the stope.

The ore body is divided into vertical blocks 15 feet square and extending from the middle level to the surface. In starting a new stope, a vertical, two-compartment raise is driven from the middle level to the upper level or to the surface. When the raise is completed, operations shift to the first floor, and the block is mined out in a series of horizontal slices. Stope sets measure 5 feet by 5 feet by 7 feet 9 inches. They are made from local Engelman spruce. The sill floor posts are 9 feet long over all, stope posts 7-1/2 feet, caps 5 feet, and girts 4 feet 8 inches. A worked out stope is filled with glacial till, which is either brought down the waste compartment of No. 2 shaft to the upper level and hand-trammed to the stopes, or dumped directly into the stopes from the surface. The stopes are filled only to the upper level. Stope production per man-shift amounts to 6.75 tons at a cost of $1.75 per ton . . . The over-all tonnage per ton of ore mined $2.25.

Open-Pit Mining

General Plan of Operations

The open pit was planned to have 8 benches 30 feet wide and 30 feet high. A spiral road with a 6-percent grade was planned to lead from the bottom of the pit to an exit at the south end. Adjustments were made as mining progressed to provide maximum production of tungsten ore. Figure 4 shows the plan of the pit at the completion of tungsten mining; the road spirals from the crushing plant to the bottom of the pit. The crushing plant and conveyor system were built in the open pit after tungsten mining was completed.

During the period when tungsten ore was being produced, the material removed from the pit was classified as follows: Tungsten-antimony-gold ore, oxidized gold-antimony ore, primary gold-antimony ore (sulfide ore) waste rock, and overburden. The tungsten-antimony-gold ore was hauled directly to the mill; the oxidized and primary gold-antimony ores were hauled to separate

Generated on 2024-09-19 18:58 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-19 18:59 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

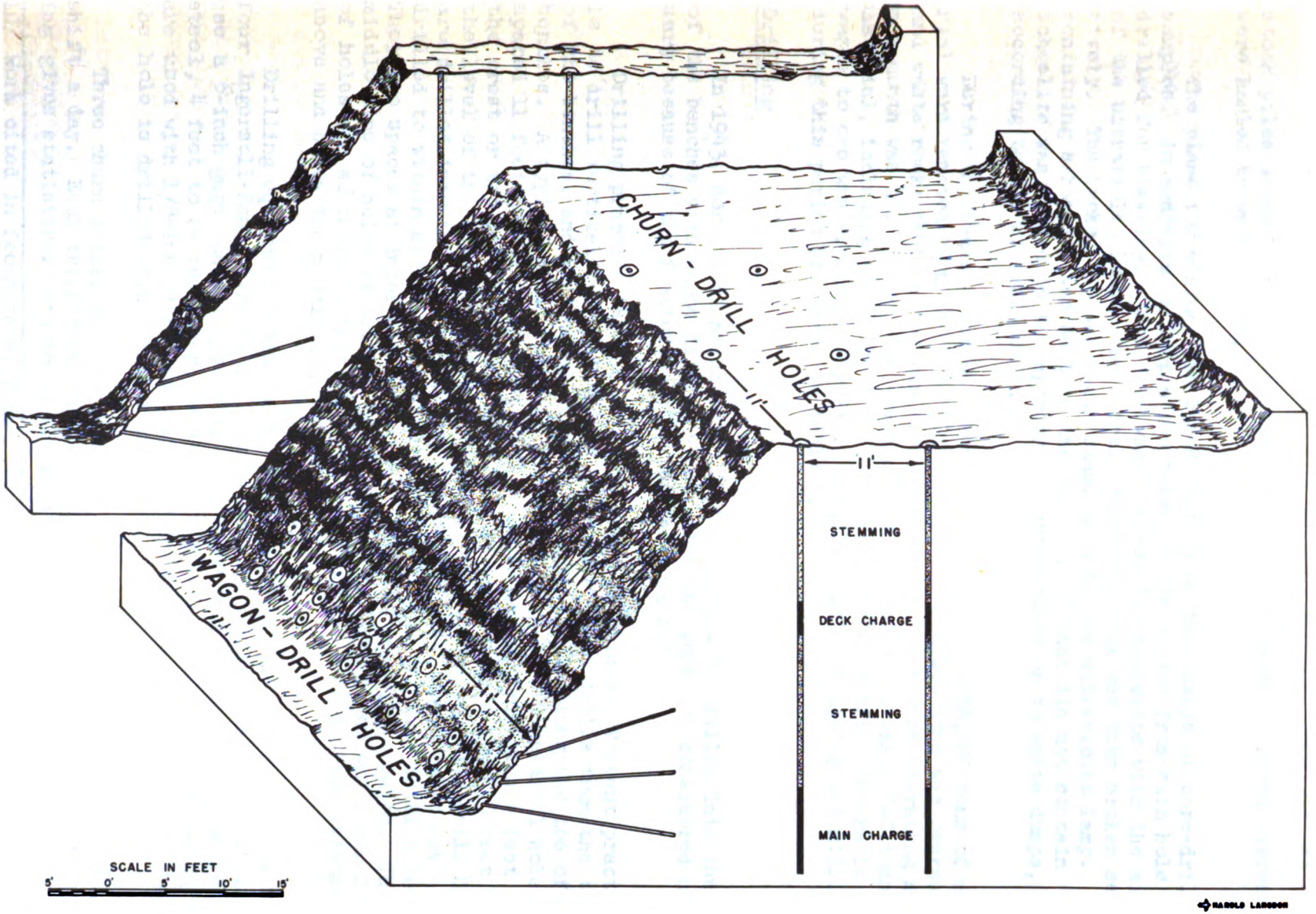


Figure 6. - Typical open-pit round.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

stock piles downstream from the open pit; and the waste rock and overburden were hauled to waste dumps.

The plans for mining were based chiefly on the assays of core-drill samples. In addition, a sample was taken of the sludge from each hole drilled for blasting. Each face was examined for scheelite with the aid of the ultraviolet lamp. The scheelite-bearing rock was then broken selectively. The broken ore was again examined with the ultraviolet lamp. Ore containing scheelite was sent to the mill. Rock that did not contain scheelite was hauled to the appropriate stock piles or to waste dumps, according to its mineral content.

During the 6-month period, January to June 1945, 256,000 tons of material were removed from the pit. Of this amount 168,000 tons was overburden and waste rock; 88,000 tons was ore. The average number of operating shifts per month was 26. Hence, the average rate of production was 1,640 tons of material, including 564 tons of ore, for each 8-hour shift. The ratio of waste to ore was approximately 2:1. Detailed costs of mining and milling during this period are given in table 7.

Drilling

In 1943, horizontal holes 18 to 24 feet long were drilled into the face of the benches with wagon drills. Vertical holes were not considered necessary because of the fractured nature of the rock.10/

Drilling practice changed as experience was gained. Present practice is to drill vertical 6-inch-diameter holes with churn drills from the top of the benches, and horizontal holes with wagon drills along the toe of the benches. A typical drill round is shown in figure 6. Churn-drill holes are spaced 11 feet apart. The first line of holes is approximately 4 feet from the crest or top of the slope. Each hole is drilled to a depth 5 feet below the level of the next lower bench. Usually three rows of wagon-drill holes are drilled into the face of the bench near the toe. These holes are drilled to within about 11 feet from the first line of churn drill holes. They are spaced at intervals 5-1/2 feet along the toe of the bench. The middle line of holes is drilled horizontally; the upper and the lower lines of holes are so inclined that they will bottom 5 to 6 feet, respectively, above and below the middle line of holes.

Drilling equipment includes two Bucyrus-Erie, type 22T churn drills and four Ingersoll-Rand, type F. H. 2 wagon-mounted drills. The churn drills use a 6-inch gage chisel type bit. The wagon drills use 1-1/2-inch round steel, 4 feet to 24 feet long, in 4-foot changes. Detachable Timken bits are used with 1/8-inch difference in gage between changes. The last run in the hole is drilled with a 2-inch-gage bit.

Three churn drills and two to three wagon drills are operated one 8-hour shift a day. Each drill crew consists of a driller and a helper. The following gives statistical data on drill operation:

10/ Work cited in footnote 9, page 13.

Generated on 2024-09-19 18:58 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

March to June 1945

Type drill	Feet drilled	Feet drilled per drill operating hour	Feet drilled per man-hour	Feet drilled per bit
Churn	5,100	4.97	2.25	8.7
Wagon	4,845	-	9.10	-

Blasting

The usual blast consists of 10 to 12 churn-drill holes spaced on 11-foot centers in 2 rows along the bench and 20 to 30 wagon-drill holes. All holes are blasted simultaneously with Primacord. The explosion is initiated with blasting cap and fuse; two blasting caps are employed to assure detonation in case one of them fails to function. This method is preferred to electric blasting, as it has been found to be simpler and requires less time to prepare. At the present rate of production, one primary blast every 1 to 2 weeks maintains the ore supply. Large fragments from the preceding blast are drilled with short holes and blasted at the same time as the primary blast.

DuPont 60-percent Gelex in 12-1/2-pound paper cartridges is used in blasting the churn-drill holes. The same make and type of explosive in 2-inch-diameter paper cartridges are used in the wagon drill holes. Past experience has shown that 4 tons of rock are broken per pound of explosive. With this as a basis, the rock burden on the holes and the quantity of explosive to be used are calculated. The charge in the churn-drill holes usually consists of 100 to 125 pounds of explosive per hole. Fine ore is used as stemming. The wagon-drill holes are loaded with approximately 3/4 pound of explosive per foot of hole.

The cartridges comprising the principal charge in the churn-drill holes are lowered to the bottom of the hole by 1/4-inch line. The top cartridge of the lower charge is pierced, and the Primacord is threaded into and tied to the cartridge before lowering. Stemming is then added, and a part of the charge, usually one to two cartridges, is "decked" farther up the hole. The Primacord is threaded through these "decked" cartridges. The hole is then filled to the collar with stemming.

The wagon-drill holes are loaded without stemming; the primer is the last cartridge to be loaded.

The blasting foreman measures the benches, spots the drill holes, and computes the charges to be used. With the assistance of the drill helpers he loads each churn-drill hole as soon as its drilling is completed. He loads the wagon-drill holes when drilling of the round is completed.

Loading

Diesel-driven power shovels are used for stripping overburden and loading ore. Four shovels are used in the pit. The general specifications of the shovels are listed on the following page.

Generated on 2024-09-19 18:59 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

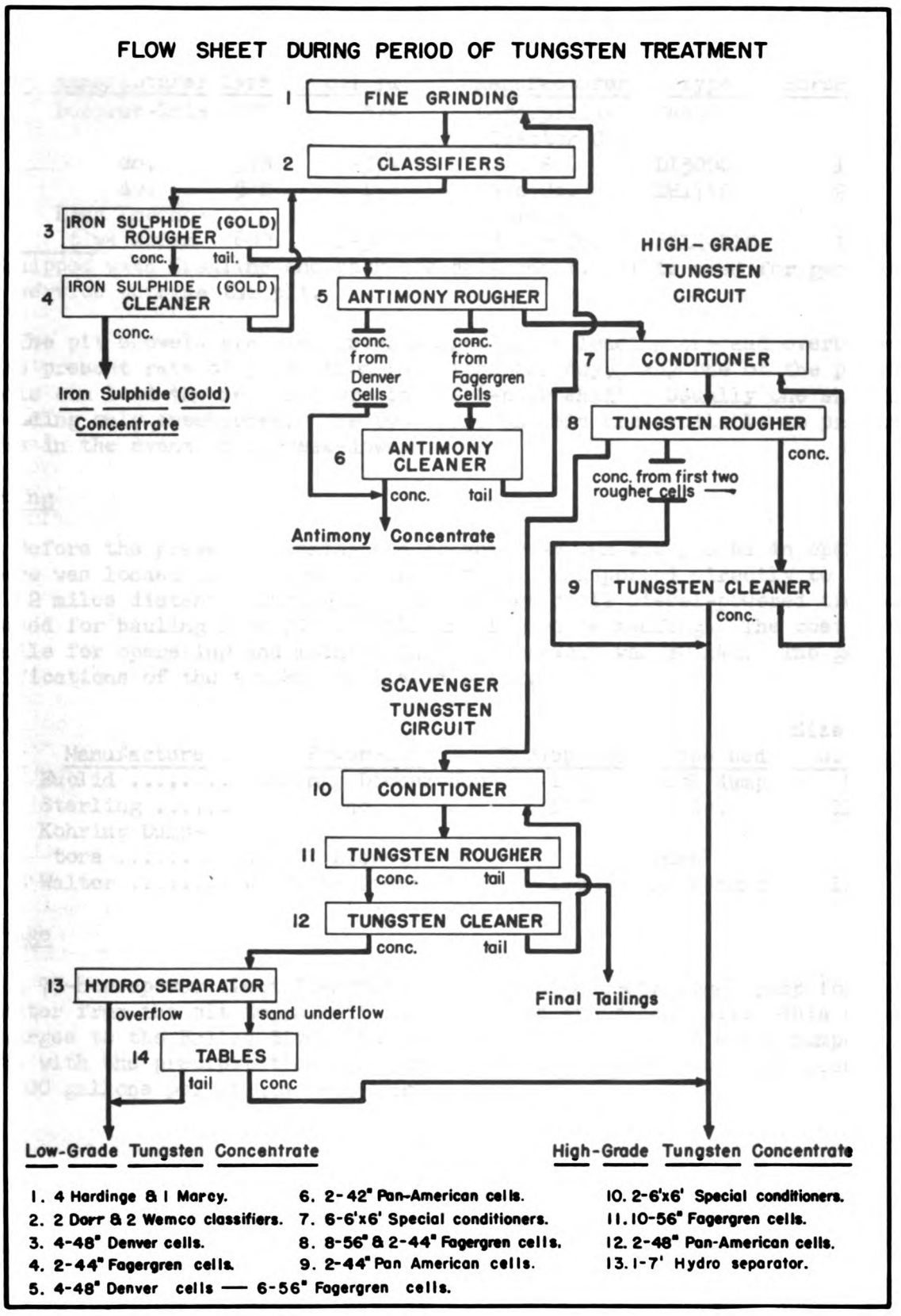


Figure 7. - Flow sheet, Yellow Pine mill.

Generated on 2024-09-19 18:58 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Number	Manufacturer	Type	Size bucket, cu. yd.	Engine manufacturer	Engine type	Horsepower
1 1/	Bucyrus-Erie	20B	3/4	Caterpillar Tractor Co.	D4400	44
2	do.	37B	1-3/4	do.	D13000	132
1	do.	54B	2-1/2	Buda Co.	DH1742	207
1	Lima Locomotive Works	602	1-3/4	Waukesha Motor Co.	6ELH-21C	135

1/ Equipped with dragline and back-hoe attachment. It is used for general service outside the pit.

The pit shovels are used interchangeably in loading ore and overburden. At the present rate of production (900 tons per day), any one of the pit shovels can load the required ore in one 8-hour shift. Usually one shovel is loading only overburden. The two spare shovels are available to prevent delays in the event of a break-down.

Trucking

Before the present crushing and conveyor system was placed in operation, the ore was loaded into trucks in the pit and transported directly to the mill, 2 miles distant. During 1945 an average of 12 Diesel-powered trucks was used for hauling from pit to mill and for waste hauling. The cost per ton-mile for operating and maintaining these trucks was $0.142. The general specifications of the trucks are listed below:

Number	Manufacture	Power-unit	Horsepower	Type bed	Size bed, cu. yd.
5	Euclid	Cummings Diesel HB6	150	Rock dump	9.7
4	Sterling	do.	150	do.	11.0
2	Kohring Dumptors	G.M.C. Diesel		Dump	5.0
1	Walter	Waukesha Diesel	175	Rock dump	12.0

Drainage

A 75-horsepower electric-motor-driven Cameron centrifugal pump forces the water from the pit to an adit in the east slope of the pit. This adit discharges to the Bailey diversion tunnel. The quantity of water pumped varies with the precipitation. In June 1946 it was estimated that less than 100 gallons per minute were pumped.

MILLING

The tungsten-antimony-gold circuit was designed originally to produce a scheelite concentrate, an antimony sulfide concentrate, and an iron sulfide (gold) concentrate. It involved two parallel flotation circuits.11/

11/ Work cited in footnote 9, p. 13.

Generated on 2024-09-19 18:58 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Subsequent experimentation led to development of the flow sheet shown diagrammatically in figure 7. A brief description of the treatment follows:

Crushing

The largest fragments of ore delivered to the crushing plant were 3 feet in maximum dimension. The ore passed over a steel grizzly to a 24-inch by 36-inch Blake crusher, which reduced it to 3-1/2 inches. The crushed ore was added to the undersize from the steel grizzly and fed to a No. 37 Kennedy crusher, which reduced it to 1-1/2 inches. It was then fed to 3- by 6-foot vibrating screens. The oversize from the screens was fed to two 3-foot Symons standard cone crushers. The crushed ore from the Symons crushers was added to the undersize from the vibrating screens and delivered to the fine-ore bins. The fine ore was all minus 1-inch.

Grinding

The ore was ground in four Hardinge ball mills and one Marcy ball mill. The sizes of the mills are listed below:

Number	Type	Size
1	Hardinge	8 foot by 36 inches
2	do.	8 foot by 48 inches
1	do.	7 foot by 36 inches
1	Marcy	8 foot by 6 foot

The pulp density was maintained at 70 to 72 percent solids in the ball mills and 38 percent solids at the classifier overflow. The combined output of the five grinding circuits was approximately 750 tons per 24 hours at a screen size of 96 percent minus 60-mesh.

Flotation

The flotation circuit consisted of one long series of cells, with a capacity of 750 tons of ore in 24 hours.

Four separate concentrates were floated in the following order: Iron sulfides (containing most of the gold), antimony sulfide (containing most of the antimony and silver), high-grade scheelite, and low-grade scheelite. Because of marketing conditions, the antimony content of the iron sulfide concentrate was held at 20 percent.

The value of the tungsten in the ore exceeded by many times the value of the combined gold, silver, and antimony. Therefore, emphasis was placed on recovery of tungsten in a high-grade concentrate. A typical analysis of the mill heads was: Tungsten trioxide, 1.50 percent; antimony, 3.2 percent; gold, 0.06 ounce per ton; and silver, 1.50 ounces per ton.

Generated on 2024-09-19 18:59 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Iron Sulfide (Gold) Circuit

The classifier overflow was pumped to a common head box that discharged to the head of a series of four 48-inch Denver cells. Head samples were taken from the head box discharge by a Geary-Jennings automatic sampler. Reagents added to the iron sulfide circuit were:

Place added	Reagent, pound per ton of ore
Ball mills	0.07 pound Xanthate 301
	.30 pound Caustic soda
Headbox	.12 pound B-23

The concentrates from the four Denver cells were treated in two 44-inch Fagergren cleaner cells. The mineral content of the concentrates from the cleaner cells averaged: Gold, 1.36 ounces per ton; silver, 8.66 ounces per ton; and antimony, 20 percent. The cleaner-cell tailings were returned to the head of the circuit. The antimony content of the iron sulfide concentrate was controlled by the quantity of caustic soda used. Only 54 percent of the gold was recovered in the iron sulfide concentrate. In addition, the iron sulfide concentrate contained 14 percent of the total antimony and 12 percent of the total silver.

Antimony Sulfide Circuit

The tailings from the iron sulfide circuit went to a series of four 48-inch Denver cells followed by six 56-inch Fagergren rougher cells. Concentrates from the Denver cells went directly to the antimony thickener. The concentrates from the Fagergren cells were treated in two 48-inch Pan-American cleaner cells. The cleaner-cell tailings were returned to the head of the antimony sulfide circuit; the cleaner-cell concentrates went to the antimony concentrate thickener. The reagents added for the antimony sulfide float were:

Place added	Reagents, pound per ton of ore
Head of circuit and to	0.91 pound lead acetate
3d Fagergren cell	.03 pound Xanthate
	.06 pound B-23

The antimony sulfide concentrates contained an average of: Antimony, 51 percent; gold, 0.20 ounce per ton; silver, 18.0 ounces per ton; and tungsten trioxide, 0.5 percent. The antimony sulfide circuit recovered an average of 64 percent of the antimony, 51 percent of the silver, 13 percent of the gold, and 1.3 percent of the tungsten trioxide.

High-Grade Tungsten Circuit

The tailings from the antimony circuit went to six 6-foot by 6-foot conditioner tanks. The conditioning time was approximately 15 minutes. The following reagents were added:

Generated on 2024-09-19 18:56 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Place added	Pounds per ton of ore
1st conditioner.....	1.0 pound caustic soda
do.	.2 pound quebracho
do.	.35 pound sodium silicate
do.	2.7 pound soda ash
Head pump	.60 pound Keminol
7th cell	.20 pound Keminol
5th conditioner	1.00 pound oleic acid
7th cell	.10 pound oleic acid

The high-grade tungsten circuit comprised eight 56-inch and two 44-inch Fagergren rougher cells. The concentrates from the first two rougher cells went directly to the concentrate thickener. The concentrates from the last eight rougher cells were treated in two 48-inch Pan-American cleaner cells. The tailings from the Pan-American cells were returned to the head of the tungsten circuit. Fifty percent of the tungsten content of the mill heads was recovered in this circuit, and the concentrates averaged 50 percent tungsten trioxide. Impurities in the tungsten concentrate included 0.50 percent phosphorus, 0.15 percent arsenic, and 0.20 percent sulfur.

Low-Grade Tungsten Circuit

The tailings from the high-grade tungsten circuit discharged into two 6- by 6-foot conditioners, where 0.67 pound per ton of Perkins pine fatty acid oil was added. The pulp from the conditioners was fed to 10 56-inch Fagergren rougher cells. The tailings from these cells constituted the final tailings for the entire circuit. The concentrates from the rougher cells were treated in two 48-inch Pan-American cleaner cells. The cleaner-cell tailings were returned to the conditioners. The cleaner-cell concentrates averaged approximately 15 percent tungsten trioxide. The tungsten recovery in this circuit was 35 to 40 percent of the tungsten trioxide content of the mill heads. The concentrates from the Pan-American cleaner cells were treated in a 7-foot hydroseparator, to which was added 7 pounds of sodium silicate for each ton of concentrate. The sand underflow from the hydroseparator went to two concentrating tables. The concentrates from the tables contained 60 to 65 percent of the tungsten content of the table feed; they assayed 45 to 55 percent tungsten trioxide. The hydroseparator overflow and the table tailings were combined into a low-grade tungsten product which averaged approximately 7 percent tungsten trioxide.

The above-described treatment resulted in a 70- to 72-percent recovery of the tungsten content of the mill heads in a high-grade (50 percent tungsten trioxide) concentrate and an additional recovery of 10 to 20 percent in a low-grade concentrate.

The low-grade tungsten product was shipped for further treatment to the plant of Metals Reserve Co., Salt Lake City, Utah; to the plant of the United States Vanadium Corp., near Bishop, Calif.; and to the plant of the Bradley Mining Co., Boise, Idaho.

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

SUMMARY OF COSTS, - OPEN-PIT MINING AND MILLING

The costs of mining and milling, before depreciation, depletion, and taxes, during a representative period are given in the following tables:

TABLE 7. - Costs, in dollars per ton of ore milled, from January to June 1945, incl. - 6 months

Tons mined: 256,611
Tons milled: 88,322
Tons waste: 169,499

	Labor	Supplies	Equipment and maintenance	Electric power	Reserve	Total
Pit mining[1]						
Drilling	$0.095	$0.048	$0.063	$	$	$0.206
Blasting	.020	.063	.002			.085
Shoveling	.046	.094	.112			.252
Waste hauling	.055	.142	.053			.250
Ore hauling	.076	.210	.068			.354
Pit maintenance	.047	.064	.061	0.015		.187
Supervision	.054	.007	.004			.065
Total	$ .393	$ .628	$ .363	$ .015		$1.399
Milling						
Crushing and conveying	.120	.031	.013	.072		.236
Grinding	.075	.152	.008	.177	0.059	.471
Flotation	.077	.408	.003	.090		.578
Filtering and drying	.033	.008	.001	.021		.063
Concentrate handling	.026	.001	.001			.038
Utility truck and operator	.001	.031	.021			.053
Tailings disposal	.001	.022	.003			.226
Mill maintenance	.079	.110	.037			.226
Supervision	.081	.002				.083
Total	$ .493	$ .765	$ .097	$ .360	$ .059	$1.774
Total - mining and milling	.886	1.393	.460	.375	.059	3.173
General[2]	1.261	1.450	.252	.073		3.036
Grand total	$2.147	$2.843	$0.712	$0.448	$0.059	$6.209

1/ Includes cost of stripping waste and stock-piling ore.
2/ Includes non-recurring mine and mill expense, road maintenance, engineering, assaying, concentrate hauling, administrative and office expense, vacation pay, boarding house, and hospital operation.

Generated on 2024-09-19 18:58 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 8. - Costs in units of labor, power, and supplies per ton of ore milled

Period covered: 4 months - March to June, 1945.

	Tons
Ore mined and milled	49,572
Waste or stock-piled ore	49,714
Overburden removed	48,930
Total material mined	145,698

		Per ton of ore milled
Open-Pit Mining[1]		
A. Labor - man-hours		
Drilling		0.120
Blasting		.017
Loading		.084
Hauling		.191
Miscellaneous		.071
Supervision		.038
Total labor		.521
Average tons of ore per man-shift	15.3	
Labor - percent of total cost of mining	28.3	
B. Supplies		
Explosives - pounds (Dupont 60 percent Gelex)		.53[2]
Supplies - percent of total cost of mining	45.0	
C. Labor and supplies - percent of total cost of mining. Equipment maintenance not included.	73.0	
Milling		
A. Labor - man-hours		
Crushing		.100
Grinding		.045
Flotation		.060
Miscellaneous (supervision, etc.)		.135
Total labor		.340
Labor - percent of total cost of milling.	27.9	
B. Supplies		
Reagents, pounds		5.37
Steel, pounds: Balls		4.03
Liners		.58
Supplies - percent of total cost of milling	43.2	
C. Power, kilowatt-hours		32.3
Power - percent of total cost of milling.	20.3	

1/ Includes cost of stripping waste and stock-piling ore.
2/ Per ton of rock broken (109,000 tons).

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

APPENDIX

TABLE 9. - Wage scale, Yellow Pine Mine

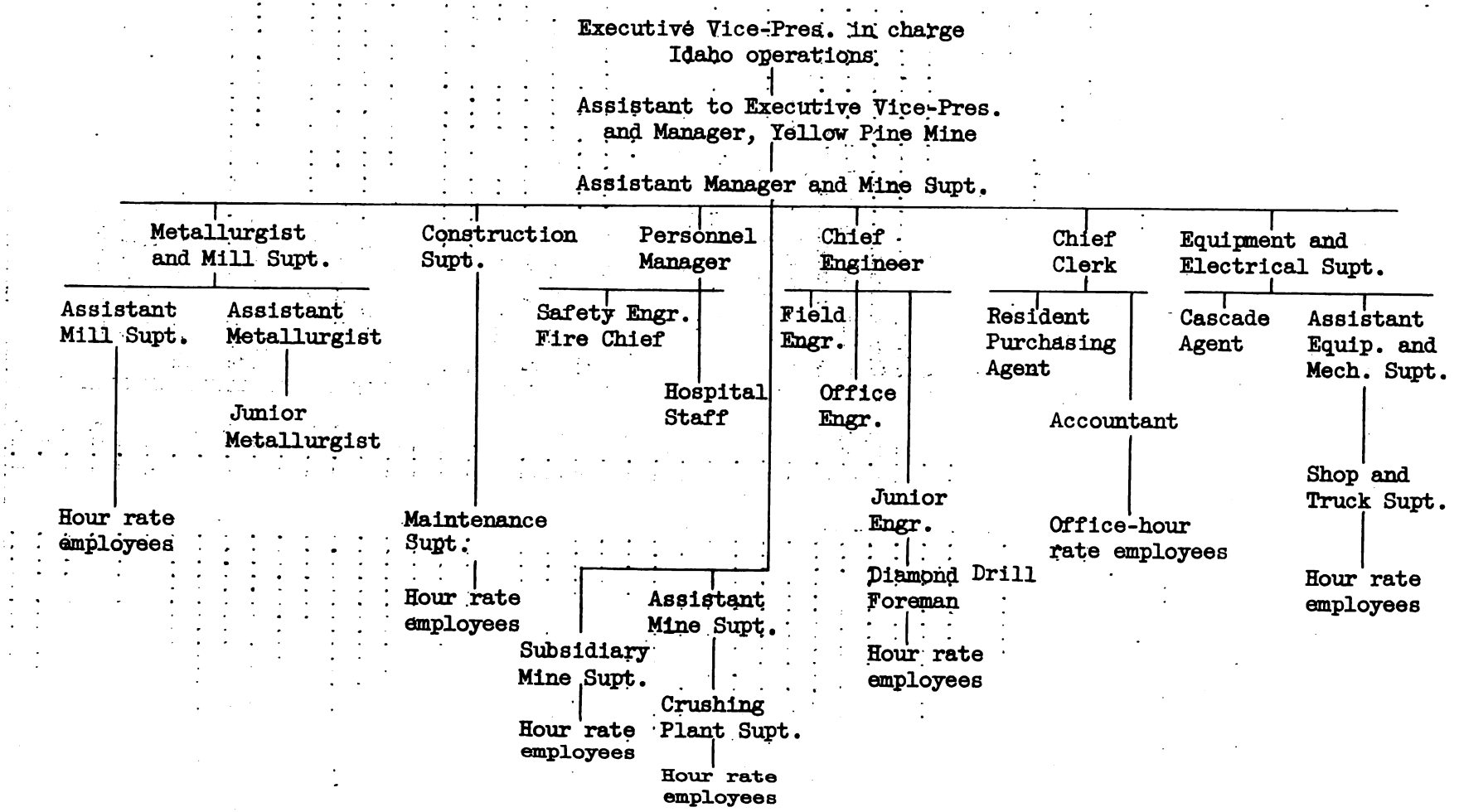
May 1, 1946

Job totle	Rate per hour	Job title	Rate per hour
Diamond drill foreman	$1.40	Flotation operator	$1.10
Electrical foreman	1.40	Powderman	1.10
Equipment-shop foreman	1.40	Second machinist	1.10
Machine-shop foreman	1.40	Loader	1.10
Construction foreman	1.40	First cook	1.00
		Shovel oiler	1.10
Millwright	1.30	Second mill mechanic	1.10
		Truck driver 5-15-ton	1.10
Diamond driller	1.25		
Accountant	1.25	Patrol operator	1.05
Mill shift boss	1.25	Assayer	1.05
First electrician	1.25	Crusherman	1.05
First equipment mechanic ...	1.25	Ball-mill operator	1.05
Powder foreman	1.25	Second warehouseman	1.05
Shovel operator	1.25	Drill helper, diamond,	
First carpenter	1.25	churn, and wagon	1.05
First machinist	1.25		
Crusher mechanic	1.25	Utility truck driver	1.00
First painter	1.25	Drill-sharpener helper	1.00
First welder	1.25		
Plumber	1.25	Filter operator	.95
Jaw-crusher operator	1.25	First clerk	.95
Development miner	1.20	Second cook	.80
First mill mechanic	1.20	Warehouse helper	.90
Tractor operator	1.20	Pastry cook	.80
		Craft helper	.90
Drill sharpener	1.15	Laborer	.90
Disbursing agent	1.15	Janitor	.90
Outside truck driver	1.15		
Second carpenter	1.15	Night watchman	.85
Wagon driller	1.15	Dishwasher	.75
Welder	1.15	Head waitress	.75
Dumptor-truck driver	1.15	Second clerk	.85
Mill statistician	1.15		
First warehouseman	1.15	Kitchen helper	.70
Snow-plow operator	1.15	Waitress	.70
Churn driller	1.15		
Second electrician	1.15	Note: Base wages during tungsten mining period were $0.10 an hour lower plus a bonus based on tungsten production.	
Truck driver 15-ton, over ..	1.15		
Equipment service man	1.15		
Second equipment mechanic ..	1.15		
Symons-crusher operator	1.15		
Second painter	1.15		
Shop statistician	1.15		

Generated on 2024-09-19 18:57 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-19 18:56 GMT / https://hdl.handle.net/2027/osu.32435030643829
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

TABLE 10. - Organization chart - Bradley Mining Co.



Digitized by Google
Original from THE OHIO STATE UNIVERSITY